Retrieval of Amplitude and Phase Contrast Images from Coherent Visible-Light Diffracted Intensities

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To compare computer simulations with experiments, and to gain some experience with experimental data for X-ray and electron experiments [1], coherent laser optical phase retrieval experiments have been performed using the hybrid input-output (HIO) algorithm [2]. The phase was successfully retrieved for several different support constraints and object types. So far, only opaque support constraints have been used, since there are much less problems with excessive central beam intensities. The light source was a frequency stabilized He-Ne Laser with wavelength λ = 632.8nm. The laser light was collimated to provide parallel illumination at the sample. The diffracted light from the sample was focused with a lens onto a liquid Nitrogen cooled CCD camera with 1024x1024 pixels (Princeton). Phase recovery was done with the HIO-algorithm implemented as a script in Gatan's Digital micrograph (DM) software. For an object with phase shift $\phi < \pi/2$ both real and imaginary part of the object exit wave ($a\cos\phi$, $a\sin\phi$) are positive and this can be used as an additional constraint in real space. A strong phase object is easier reconstructed with a support consisting of two separated areas. Mica sheets across holes where used as phase objects. Resolution test patterns with transparent numbers and bars in an opaque chrome film on glass where used as real objects. Experimental diffraction patterns with different exposure times had to be merged to one pattern to avoid overexposure and blooming around the central spot. An object, which was on a different plane (out of focus) relative to the support holes, could be reconstructed. The object could be focused again using the recovered complex exit wave and the correct Fresnel propagator. The experiments show, that in general a two-hole support (or two particles on a transparent support) is favorable for phase recovery and is necessary for strong objects. Real objects and weak-phase objects can be recovered with a loose support, whose size can be estimated from the autocorrelation.

[1] U. Weierstall, J.C.H. Spence, *Image reconstruction from electron and X-ray diffraction patterns using iterative algorithms :experiment and simulation,* submitted to Ultramicroscopy 2001

[2] J.R. Fienup, *Phase retrieval algorithms: a comparison,* Applied Optics 21 (1982) 2758